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Ecotoxicity Testing of Nanoparticles for Remediation of Contaminated Soil and Groundwater

Rune Hjorth[1], Claire Coutris[2], Nhung Nguyen[3], Alena Ševců[3], Anders Baun[1] and Erik Joner[2]

[1]Technical University of Denmark, [2]Bioforsk, [3]Technical University of Liberec

www.nanorem.eu

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Background and Objectives

As innovation in remediation technology brings new solutions to old problems, regulatory bodies will require hazard and safety data as new technologies are brought from lab-scale to real-world application.

Going beyond zero-valent iron

A range of nanomaterials are developed in NanoRem in order to extend the spectrum of treatable soil and groundwater contaminants from halogenated organics to non-halogenated substances and non-reducible metals.

Contributing to hazard assessment of nanomaterials

These nanomaterials are meant to help solve the environmental problem of contaminated soil and groundwater, not to create additional ones. Therefore, it is important that their intrinsic toxicity is assessed, as required under REACH.

Ecotoxicity tests

We have tested a range of particles developed for remediation purposes, using standard ecotoxicity tests to assess their potential hazard towards groups of organisms used for hazard identification for classification and labeling purposes.

- Bacteria — *Vibrio fischeri*, 15 min luminescence, ISO 11348-3
- Algae — *Pseudokirchneriella subcapitata*, 48h growth, OECD 201
- Crustacean — *Daphnia magna*, 48h immobilization, OECD 202
- Earthworm — *Eisenia fetida*, 48h mortality, OECD 207
- Plant — *Raphanus sativus, L. multiflorum*, 6d root length, OECD 208

Besides the standardized protocols, we also tested the particles effect on:

- Bacteria — *Escherichia coli*, 6h growth and 24h cell viability
- Algae — *Chlamydomonas sp*., 48h photosynthesis efficiency
- Oligochaete — *Lumbriculus variegatus*, 96h mortality

The tested particles were dispersed as recommended by the producers and the suspensions were characterization by DLS, NTA, ORP, and pH.

Nanomaterials

Carbo-Iron

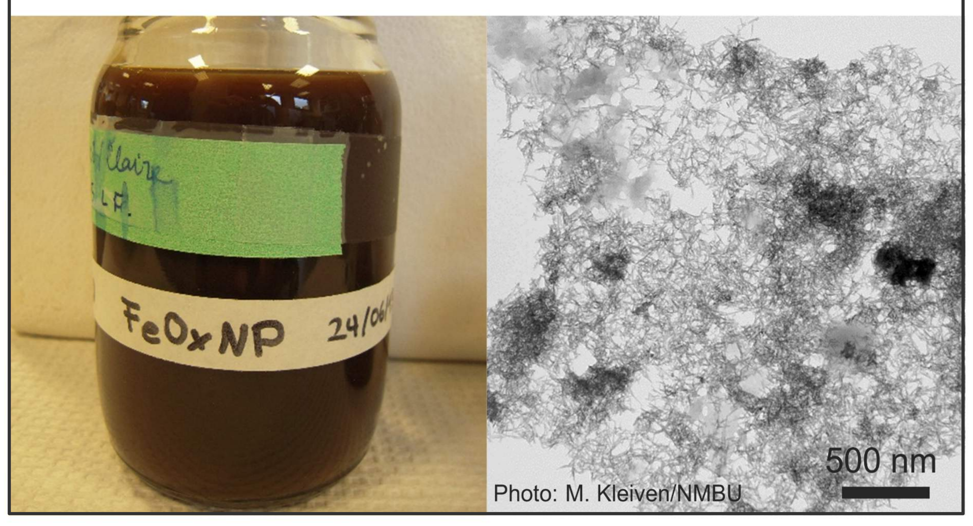
- Composite of activated carbon and zero-valent iron
- Adsorption and reduction of halogenated contaminants

Fe Zeolites

- Nanoporous aluminosilicate loaded with iron Fe^{3+} catalyst
- Oxidation of small molecules, e.g. BTEX, MTBE, dichloroethane, and chloroform

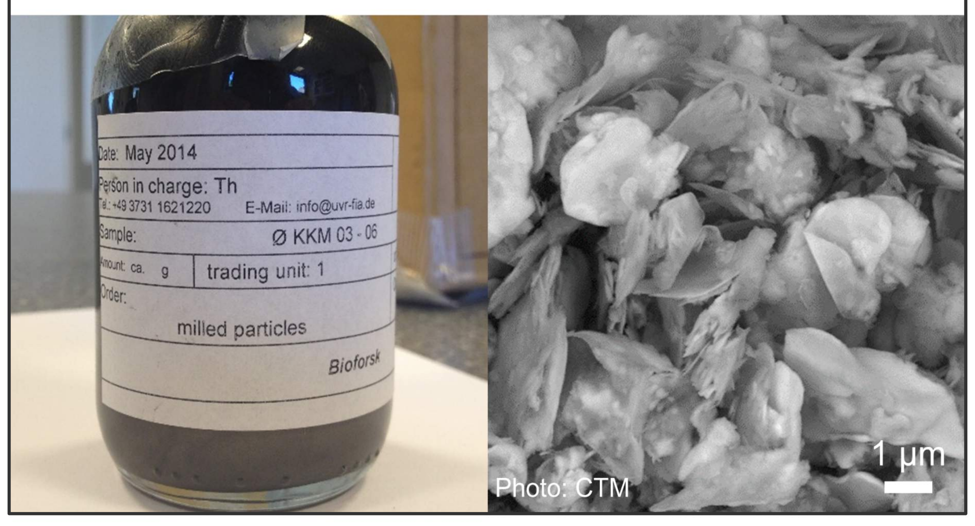
Fe Oxides

- Pristine iron oxides, mostly goethite $Fe^{3+}O(OH)$ stabilized with humic acids
- Oxidation (catalytic effect on bioremediation) of biodegradable contaminants, such as BTEX



Milled zero-valent iron

- Mechanically ground zero-valent iron
- Reduction of halogenated contaminants (same spectrum as for nZVI produced by thermal reduction)



Results and Discussion

EC_{50} >100 mg/L

EC_{50} <100 mg/L

Carbo-Iron									
Fe Oxides									
Fe Zeolites									
Milled ZVI	ND	ND	ND				ND		

Standard ecotoxicity testing of nanoparticles has in general proven technically difficult and it may be questioned whether proper hazard identification of engineered nanoparticles needed for environmental risk assessment is currently feasible. Aggregation, agglomeration, sedimentation, shading, and other physical effects are known to confound the measuring principles behind the tests and these inferences were also observed for the tested particles.

This was pronounced for tests on algae, bacteria, and crustaceans and require inclusion of additional controls to ensure a correct data interpretation. E.g. a reduction in luminescence is seen as a sign of toxicity in the *V. fischeri* assay, but the turbidity of the tested particles absorb the light emitted by the bacteria before detection and is thus not a toxic effect.

Conclusion

The low toxicities found in the standard organisms do not lead to any hazard classification according to EU regulation for any of the tested particles and the results indicate that the particles, except the milled ZVI particles, can be considered non-toxic.

Nanomaterials with the lowest toxicity profile should be preferred over other materials with similar field scale efficacy and reactivity towards the target contaminants.

[1]Department of Environmental Engineering, Technical University of Denmark
Miljøvej, Building 113, 2800 Kgs. Lyngby, Denmark
Correspondence to ruhj@env.dtu.dk

[2]Department for Soil Quality and Climate, Bioforsk
Høgskoleveien 7, 1430 Ås, Norway

[3]Institute for Nanomaterials, Advanced Technologies and Innovations, Technical University of Liberec
Studentská 2, 46117 Liberec, Czech Republic

NanoRem - Taking Nanotechnological Remediation Processes from Lab Scale to End User Applications for the Restoration of a Clean Environment

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